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TO: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

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EXAMINER : Chambliss, alonzo
TITLE : GROOVED HEAT SPREADER
FOR STRESS REDUCTION IN IC PACKAGE

AMENDMENT AND RESPONSE TO OFFICE ACTION

Sir:

In response to an office action mailed on 09/12/02 please consider the following amendments and remarks with respect to the above referenced application.

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal service as First Class mail in an envelop addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231, on December 11, 2002.

Stephen B. Ackerman (Reg. No 37,761)

_____ 12/11/02
Signature Date

AMENDMENTS

IN THE SPECIFICATION

1) page 12, last paragraph, page 13, first paragraph, please replace this text with the following:

Referring now specifically to Figs. 4a through 4d, Fig. 4a shows in cross section the package of the invention with heat spreader 40 in which grooves 42 have been provided. The grooves divide the heat spreader 40 into a number of sections, determined by the number of grooves that are provided in a surface of heat spreader 40. For the example of heat spreader 40 that is shown in top view in Fig. 4c, two grooves 42 are provided dividing the heat spreader into four sections. For the example of heat spreader 44 that is show in top view in Fig. 4d, four grooves 46 are provided dividing the heat spreader into nine sections. This dividing of the heat spreader results in the separate sections of the heat spreader functioning in an almost independent manner, whereby the typical stresses that occur in the surface of the heat spreader are now diverted to the (regions of) the grooves. In concentrating thermal and mechanical stresses from across the surface of the heat spreader to the regions of the grooves of the heat spreader, these

stresses are greatly reduced in the surface of the semiconductor die 12, the solder bumps 11 and the contact balls 26. This placement of the stress in the regions of the grooves results in enhanced reliability performance of the semiconductor die 12 and the underlying substrate 10 on which the die is mounted. In addition, thermal and mechanical stress will be reduced on points of electrical contact that are used to interconnect die 12 such as the solder bumps 11 and the contact balls 26. Since the number of grooves that is provided in the surface of the heat spreader is limited, no significant amount of material of the heat sink is removed which results in little or no negative impact on the thermal performance of the package. Grooves 42 and 46 can be created using methods of etching, machining or punching of the surface of the heat spreader.

2) page 1, the title of the invention, please replace the first-line entry with the entry METHOD OF FABRICATING AS GROOVED HEAT SPREADER FOR STRESS REDUCTION IN AN IC PACKAGE

IN THE CLAIMS

Please amend the claims as follows:

1. (Amended) A method of applying a heat spreader in a semiconductor package, comprising the steps of:

providing a semiconductor die;

providing a substrate over the surface of which the semiconductor device is to be mounted;

providing a stiffener for the semiconductor package;

mounting the semiconductor device over the substrate, providing an adhesive interface for the stiffener, placing the stiffener in position and establishing electrical contact between the semiconductor device and the substrate; providing a heat spreader having a first and a second surface for a semiconductor package, the heat spreader having been provided with at least one groove across said heat spreader;

providing an adhesive interface for the heat spreader; and

placing the heat spreader over the adhesive interface there-of.

2. (Amended) The method of claim 1, said heat spreader being a rectangular cube having parallel first and second surfaces of equal surface area bounded by four interconnecting surfaces, a

surface area of said interconnecting surfaces being smaller than the surface area of said first and second surfaces by an amount, the first surface of said heat spreader facing the semiconductor die after mounting said die in the semiconductor package of which said heat spreader is an integral part.

4. (Amended) The method of claim 1 wherein said at least one groove comprises four grooves, a first and a second of said four grooves intersecting a third and a fourth of said four grooves, said first and said second of said four grooves being provided at a distance from first side boundaries of said first surface, said third and said fourth of said four grooves being provided at a distance from second side boundaries of said first surface.

5. (Amended) The method of claim 1 wherein said at least one groove comprises a multiplicity of grooves, a first half of said multiplicity of grooves intersecting a second half of said multiplicity of grooves, said first half of said multiplicity of grooves being provided at distances from first side boundaries of said first surface, said second half of said multiplicity of grooves being provided at distances from second side boundaries of said first surface.

Claims 7-10: please cancel claims 7-10.

11. (Amended) A method of creating a semiconductor package, comprising the steps of:

providing a semiconductor device mounting support, said semiconductor device mounting support having a first and a second surface, first points of electrical contact having been provided in said first surface of said semiconductor device mounting support, second points of electrical contact having been provided in said second surface, one or more layers of interconnect lines having been provided in said semiconductor device mounting support or on the first or second surface of said semiconductor device mounting support;

providing a semiconductor device, said semiconductor device having been provided with points of electrical contact in a first surface of said semiconductor device;

positioning said semiconductor device above the second surface of said semiconductor device mounting support, said first surface of said semiconductor device facing said second surface of said semiconductor device mounting support, aligning and establishing contact between said points of electrical contact provided in said first surface of said semiconductor device and said points of electrical contact provided in said second surface of said semiconductor device mounting support;

establishing electrical continuity between said points of electrical contact provided in said first surface of said

semiconductor device and said points of electrical contact provided in said second surface of said semiconductor device mounting support by a reflow of said points of electrical contact provided in the first surface of said semiconductor device;

providing an underfill for said semiconductor device, leaving a second surface of said semiconductor device exposed;

applying a first adhesive layer over the second surface area of the said semiconductor device mounting support that is not being covered by said underfill;

providing a semiconductor device stiffener having a first and a second surface, said stiffener having been provided with an opening penetrating from said first to said second surface of said stiffener and of adequate size for insertion of said semiconductor device;

positioning said stiffener over the first adhesive layer applied over the second surface of said semiconductor device mounting support, said first surface of said stiffener facing said first adhesive layer, said opening provided in said stiffener being aligned with said semiconductor device mounted on the second surface of said semiconductor device mounting support, said stiffener making contact with said first adhesive layer;

applying a second adhesive layer over the second surface of said semiconductor device and the second surface of said stiffener;

providing a heat spreader having a first and a second surface, said first surface of said heat spreader having been provided with a pattern of grooves, said pattern of grooves comprising at least one groove dividing the surface area of said first surface in sections;

positioning the first surface of said heat spreader over the surface of said second adhesive layer;

providing said first surface of said semiconductor device mounting support with a solder mask, openings in said solder mask exposing said contact points provided in said first surface of said semiconductor device mounting support;

inserting solder balls into said openings provided in said solder mask; and

establishing electrical continuity between said solder balls inserted in said openings in said solder mask and said contact points provided in said first surface of said semiconductor device mounting support by a process of reflow.

14. (Amended) The method of claim 11 wherein said pattern of grooves comprises four grooves, a first and a second of said four grooves intersecting a third and a fourth of said four grooves, said first and said second of said four grooves being provided at distances from first side boundaries of said first surface, said third and said fourth of said four grooves being provided at distances from second side boundaries of said first surface.

15. (Amended) The method of claim 11 wherein said pattern of grooves comprises a multiplicity of grooves, a first half of said multiplicity of grooves intersecting a second half of said multiplicity of grooves, said first half of said multiplicity of grooves being provided at distances from first side boundaries of said first surface, said second half of said multiplicity of grooves being provided at distances from second side boundaries of said first surface.

Claims 17-21: please cancel claims 17-21.

REMARKS

The Examiner's Final Election and Restriction requirement is acknowledged. Non-elected claims 7-10 and 17-21 have been

cancelled, a divisional application will be filed at a later date. Claims 1-6 and 11-16 are pending under this Office Action.

Examiner Alonzo Chambliss is thanked for thoroughly reviewing the instant application and for examining the Prior Art.

Favorable reconsideration of this application in light of the above amendments and the following remarks is respectfully requested.

A new design is provided for the heat spreader of a semiconductor package. Grooves are provided in a surface of the heat spreader, subdividing the heat spreader for purposes of stress distribution into four or more sections. This division of the heat spreader results in a reduction of the mechanical and thermal stress that is introduced by the heat spreader into the device package. Mechanical and heat stress, using conventional heat spreader designs, has a negative, stress induced, effect on the semiconductor die, on the contact points (bump joints) of the semiconductor die and on the solder ball connections of the package.

Specification

Reconsideration of the objection to the specification is respectfully requested based on the following.

The claims have been amended by removing the terms "in accordance with a first equation" and "in accordance with a second equation" from the claims.

A new and more descriptive title for the invention has been provided, thereby using the new title as kindly suggested by Examiner.

In light of the foregoing response, applicant respectfully requests that the Examiner's objection to the specification be withdrawn.

Claim Objections

Reconsideration of the claim objections is respectfully requested based on the following.

The Examiner is thanked for pointing out the various antecedent basis problems and errors in the claims. The claims have been carefully reviewed and amended to correct those problems and errors the Examiner pointed out, in addition to others. All claims are now believed to be in allowable condition.

In light of the foregoing response, applicant respectfully requests that the Examiner's claim objections be withdrawn.

Claim rejections - 35 U.S.C. § 112

Reconsideration of the rejection of claims 2, 4, 5, 14 and 15 under 35 U.S.C 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention is respectfully requested based on the following.

The Examiner is thanked for pointing out the antecedent basis problem in claim 2. The claim 2 has been amended to correct this problem the Examiner pointed out. Claim 2 is now believed to be in allowable condition.

In addition, claims 4, 5, 14 and 15 have been amended by removing the terms "in accordance with a first equation" and "in accordance with a second equation" from these claims.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 2, 4, 5, 14 and 15 under 35 U.S.C 112, second paragraph, be withdrawn.

Claim rejections - 35 U.S.C. § 102

Reconsideration of the rejection of claims 1-3 and 6 under 35 U.S.C 102(e) as being anticipated by Braasch (US Patent 6,437,438) is respectfully requested based on the following.

Braasch provides for a method and apparatus to limit eddy current in a thermal plate, specifically:

- a substrate 110, over which is provided
- a packaging array 120, over which is provided
- a die 130, over which is provided
- a thermal plate 160, separated from the substrate 110 by means of
- mounting pedestal 140.

The thermal plate 160 comprises a grid pattern 170 of grooves that eliminates or significantly reduces eddy current in the surface of the thermal plate 160.

The grid pattern provided by Braasch, Fig. 2 of Braasch, comprises a first group of lines 210 and a second group of lines 220. The lines that form the groups are non-periodic in that distances between two adjacent lines are not the same (col. 3, lines 13 e.a.), the distances (col. 3, lines 23 e.a.) are determined by the frequency of the electronic system and the properties of the metal.

Fig. 3 of Braasch further provides a novel groove pattern, the directions of the (relatively large number of) grooves being determined such that optimum eddy current cancellation is achieved over the surface of the thermal plate 160.

While therefore Braasch provides for and concentrates on eliminating eddy current in the surface of a thermal plate, the instant claimed invention provides a semiconductor device package comprising a heat spreader, whereby the design of the heat spreader is such that stress is significantly reduced in surfaces of the package.

Grooves are provided in a surface of the heat spreader of the instant claimed invention, subdividing the heat spreader for purposes of stress distribution into multiple sections. This is specified in claim 1: "the heat spreader having been provided with at least one groove across said heat spreader". This division of the heat spreader results in a reduction of the mechanical and thermal stress that is **introduced** by the heat spreader **into the device package**, thereby eliminating negative, stress induced effects **on the semiconductor die**, **on** the contact points (bump joints) of the semiconductor die and **on** the solder ball connections of the package.

For further application of the heat spreader of the instant invention, claim 3, additional grooves ("comprises two grooves") are specified whereby these two grooves intersect. Further, claim 4, and as yet another extension of the instant invention, the number of grooves can be increased to four, whereby these four grooves are carefully specified in order to meet the objective of the instant invention, of providing a semiconductor device package comprising a heat spreader, whereby the design of the heat spreader is such that stress is significantly reduced in surfaces of the package. This concept is further extended by additional dependent claims such as claim 5.

The semiconductor package of the instant invention is unique and differs considerably from the package that is provided by Braasch, as can be readily concluded by comparing Fig. 1 of Braasch with Figs. 4a and 4b of the instant invention. In addition, the pattern of grooves that is provided by Braasch differs significantly from the grooves that are provided by the instant invention, as is readily apparent by comparing Figs. 2 and 3 of Braasch with Figs. 4c and 4d of the instant invention.

Braasch provides for eliminating eddy currents and for this purpose provides for a large number of grooves over the surface of the thermal plate such that no uninterrupted surface area of a relatively large size remains in tact. A larger surface area of the thermal plate enables the occurrence of eddy currents in the surface of the thermal plate. The instant invention does not provide for elimination of eddy currents and therefore does not require a (very) large number of grooves in the surface of the heat sink, as is evidenced by the top views of the heat sink that is shown in Figs. 4c and 4d of the instant invention.

In comparing the Figs. 4a and 4b of the instant invention with Fig. 1 of Braasch, providing a package-to-package comparison, a significant difference must further be noted: the thermal plate of Braasch overlies the die 130 and is separated

from substrate 110 by mounting pedestals 140, without thereby allowing for a direct physical contact between the die 130 and the thermal plate 160.

Because of this, the thermal plate 160 of Braasch cannot have an effect on mechanical stress distribution within the IC package provided by Braasch since there is no way that the thermal plate 160 mechanically affects the die 130. The proximity between the thermal plate 160 and the die 130 results in eddy currents being introduced by the electromagnetic field surrounding the die 130 into the thermal plate 160. The grooves provided by Braasch reduce or eliminate these induced eddy currents.

In the package of the instant invention by contrast, a cross section of which is shown in Figs. 4a and 4a, the heat spreader 40/44 is in direct physical contact (via layer 15 of adhesive material) with the die 12 (required for optimum heat exchange between the die 12 and the heat spreader 40/44). This results in a stress pattern in the heat spreader being further propagated throughout the package, most notable into the die and sensitive contact points of the package (the contact balls 26 for instance). The grooves of the instant invention, such as grooves 42 (Fig. 4a) and 46 (Fig. 4b) disrupt the stress pattern

in the heat spreader to the point where stress is no longer transferred from the heat spreader 40/44 to contacting points or surfaces of the IC package of the invention.

In addition, the grooves of the instant invention essentially run parallel with sides of the heat sink, since such a construction optimally meets the objective of the instant invention. By contrast, the grooves provided by Braasch have a random direction whereby the (only) significant design parameter is that no (relatively large) surface area remains in place over the surface of the thermal plate.

This is specified in detail in the claims of the instant invention, as follows and thereby highlighting differences between Braasch and the instant invention, using claim 1 of the instant invention as an example:

- providing a stiffener for the semiconductor package
- mounting the semiconductor device over the substrate, providing an adhesive interface for the stiffener, placing the stiffener in position and establishing electrical contact between the semiconductor device and the substrate

- providing a heat spreader having a first and a second surface for a semiconductor package, the heat spreader having been provided with at least one groove across the heat spreader
- providing an adhesive interface for the heat spreader, and
- placing the heat spreader over the adhesive interface thereof
- the at least one groove can be extended to two (or more) grooves provided at distances from side boundaries of the first surface, the two grooves intersecting.

The above quoted paragraph reflects claims 1 and 2 of the instant invention, highlighting the differences between the instant invention and the Braasch invention.

Claim 6 provides further detail relating to the creation of the grooves that are provided by the instant invention in the surface of a heat spreader.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 1-3 and 6 under 35 U.S.C 102(e) as being anticipated by Braasch (US Patent 6,437,438), be withdrawn.

Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 4 and 5 under 35 U.S.C 103(a) as being anticipated by Braasch (US Patent 6,437,438) as applied to claim 1 above is respectfully requested based on the following.

The relative merits of Braasch with respect to the instant invention have been discussed supra and need not be repeated at this time. The discussion of these relative merits is enclosed at this time by reference thereto.

Amended claim 4 specifies four grooves, a first and a second of the four grooves intersecting a third and a fourth of the four grooves, the first and the second of the four grooves being provided at a distance from first side boundaries of the first surface, the third and the fourth of the four grooves being provided at a distance from second side boundaries of the first surface.

From amended claim 4 it is clear that the grooves of the instant invention essentially run parallel with sides of the heat sink of the semiconductor package while the heat spreader of the instant invention is in direct physical contact with the

die, which is required for optimum heat dissipation away from the die 12. This as opposed to the grooves that are provided by Braasch, as evidenced in the top view of Fig. 3 of Braasch, wherein the grooves intersect with sides of the heat spreader under an angle other than a 90 degree while the heat spreader provided by Braasch does not make direct physical contact with the mounted die, thereby reducing thermal interchange between the die and the heat spreader, limiting the package provided by Braasch.

This design of the grooves of the instant invention is not in accordance with the design of the grooves that are provided by Braasch, which, col. 2, lines 52 e.a.: "the grid of grooves 170 on the thermal plate 160 is designed not to coincide with the resonant frequencies, essentially reducing the eddy current resulting in reduced radiation emission."

Claim 5 of the instant invention extends the grooves of the instant invention to a multiplicity of grooves, this multiplicity of grooves being provided such that, in accordance with the objectives of the instant invention:

- stress is significantly reduced in surfaces of the semiconductor device package of the instant invention

- for purposes of stress distribution, dividing the surface of the heat spreader into multiple sections
- resulting in a reduction of the mechanical and thermal stress that is conventionally introduced by the heat spreader into the device package, and
- reducing a negative, stress induced effect on the semiconductor die, on the contact points (bump joints) of the semiconductor die and on the solder ball connections of the package.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 4 and 5 under 35 U.S.C 103(a) as being anticipated by Braasch (US Patent 6,436,438) as applied to claim 1, be withdrawn.

Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 11-16 under 35 U.S.C 103(a) as being unpatentable over Mertol (US Patent 5,866,943) and the Admitted Prior Art in view of Braasch (US Patent 6,436,438 is respectfully requested based on the following.

The relative merits of Braasch with respect to the instant invention have been discussed supra and need not be repeated at this time. The discussion of these relative merits is enclosed at this time by reference thereto.

Mertol provides for a grid array device package employing electromagnetic shielding. In the package that is provided by Mertol, provisions are made for creating a grid array device package, employing electromagnetic shielding, as described in detail in the specification provided by Mertol and included herein by reference without re-stating the information that is provided by Mertol.

Neither Mertol nor Admitted Prior Art however provide for, as specified in claim 11, a heat spreader having a first and a second surface, the first surface of the heat spreader having been provided with a pattern of **grooves**, the pattern of grooves comprising at least one groove dividing the surface area of the first surface in sections.

A key difference therefore between Mertol or the Admitted Prior Art and the instant invention is the provision of grooves over the surface of the heat spreader. The merits of the grooves that are provided by Braasch have been discussed supra and have

been argued as being different in design and implementation and objectives from the design, implementation and objectives of the grooves of the instant invention. The fact that Mertol does not address providing grooves highlights the fact that Mertol does not address nor provide for the basic aspects and objectives of the instant invention, that is:

- significantly reducing stress in surfaces of the semiconductor device package of the instant invention
- dividing, for purposes of stress distribution, the surface of the heat spreader into multiple sections
- reducing the mechanical and thermal stress that is conventionally introduced by the heat spreader into the device package
- reducing a negative, stress induced effect on the semiconductor die
- reducing a negative, stress induced effect on the contact points (bump joints) of the semiconductor die, and
- reducing a negative, stress induced effect on the solder ball connections of the package.

While applicant acknowledges the teachings of Mertol and Braasch as cited by the Examiner, and although applicant does not necessarily agree that the Examiner's arguments show

sufficient and proper basis for suggestion or motivation to modify or combine Mertol with Braasch, applicant nonetheless also asserts that there is absent within the portions of Mertol and Braasch or any combination thereof, as cited by the Examiner, an express or inherent teaching of each and every limitation within applicant's invention as taught and claimed within claim 11.

In this regard, applicant claims that there is absent form the portions of Mertol and Braasch or any combination thereof, as cited by Examiner, a teaching of providing grooves in the surface of a heat sink with the above stated objectives of reducing stress in surfaces of the semiconductor device package, of reducing the mechanical and thermal stress introduced by the heat spreader into the device package, of reducing a negative, stress induced effect on the semiconductor die, on the contact points (bump joints) of the semiconductor die and on the solder ball connections of the package.

It is not be obvious to combine the teachings of Mertol with those of Braasch, since there is no suggestion or motivation in the teachings of any of the patents of the present invention. Contrary to the Examiner's assertion that Braasch discloses forming grooves for purposes of stress relieve,

Braasch does not mention stress relieve but provides a method for reducing eddy currents in the surface of a thermal plate.

None of the applied or known references address the invention as shown in the claims in which stress is concentrated in surface areas of the heat sink by creating grooves for that purpose in the surface of the heat sink. The invention is believed to be patentable over the prior art cited, as it is respectfully suggested that the combination of these various references cannot be made without reference to Applicant's own invention.

None of the applied references address the problem of stress relieve when creating a semiconductor device package. Applicant has claimed his process in detail. The processes of Figs. 4a-4d are both believed to be novel and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. We believe that there is no such basis for the combination. We therefore request Examiner Alonzo Chambliss to

reconsider his rejection in view of these arguments and the amendments to the Claims.

With respect to claim 12, this claim specifies a semiconductor device mounting support selected from the group consisting of a Printed Circuit Board and a metallized structure and a glass substrate, making the instant invention more universally applicable.

With respect to claim 13, this claim is more specific regarding the pattern of grooves provided by the instant invention, further limiting the creation of grooves for purposes of stress relieve.

With respect to claim 14, this claim makes the application of the stress reducing grooves very specific by specifying a pattern of four grooves, a first and a second of the four grooves intersecting a third and a fourth of the four grooves, the first and the second of the four grooves being provided at distances from first side boundaries of the first surface, the third and the fourth of the four grooves being provided at distances from second side boundaries of the first surface.

It is clear that a pattern of grooves, created in accordance with claim 14, differs significantly from the grid of grooves that is provided by Braasch, as previously highlighted and as is evident by comparing the various related drawings (Figs. 2 and 3 of Braasch versus Fig. 4a-4d of the instant invention).

Regarding claim 15, this claim further extends the instant invention by providing for a multiplicity of grooves. It is clear that such a specification is required since without such a specification the instant invention would be limited in the number of grooves that can be provided. The relative merits of the grooves that are provided by Braasch compared with the grooves that are provided by the instant invention have been discussed above and are enclosed at this time by reference.

Claim 16 provides detail of creation of the grooves of the instant invention, wherein the pattern of grooves is provided using methods of etching or machining or punching of the first surface of the heat spreader.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 11-16 under 35 U.S.C 103(a) as being unpatentable over Mertol (US Patent

5,866,943) and the Admitted Prior Art in view of Braasch (US Patent 6,436,438, be withdrawn.

Other Considerations

No new independent or dependent claims have been written as a result of this office action, no new charges are therefore incurred due to this office action.

SUMMARY

A new design is provided for the heat spreader of a semiconductor package. Grooves are provided in a surface of the heat spreader, subdividing the heat spreader for purposes of stress distribution into four or more sections. This division of the heat spreader results in a reduction of the mechanical and thermal stress that is introduced by the heat spreader into the device package. Mechanical and heat stress, using conventional heat spreader designs, has a negative, stress induced, effect on the semiconductor die, on the contact points (bump joints) of the semiconductor die and on the solder ball connections of the package.

It is requested that should Examiner not find the claims to be allowable that he call the undersigned Attorney at his convenience at 845-452-5863 to overcome any problems preventing allowance.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned:

"Version with markings to show changes made."

Respectfully submitted,

Stephen B. Ackerman (Reg. No 37,761)